EFFECTS OF CONTOURED PALLETS ON AMC MISSION EFFICIENCY

GRADUATE RESEARCH PAPER

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Abstract

Pallets airlifted on Boeing 747s and MD-11s in fiscal year 2009 were analyzed to determine the effects of redistributing cargo from full cubes to contoured shapes. Specifically, the research analyzed the possibility of structuring pallet build strategies that would ensure that MD-11 missions were not cancelled due to lack of available contour-compatible cargo while other, full-cubed cargo was available. Missions were tracked on these airframes between Dover Air Force Base, Delaware and Incirlik Air Base, Turkey. Data was obtained from Air Mobility Command and then used to construct four different models to examine the effects of redistribution. The data consisted of over 22,000 pallets moved on over 600 missions.

The models demonstrated that opportunities to restructure cargo to build more contour-compatible pallets exist and these opportunities have the potential to not only avoid future costs due to mission cancellation fees, but also increase the efficiency of the system as a whole. The models demonstrated that this opportunity to increase efficiency may exist to a much greater degree in pallets built at the aerial ports than those built at Defense Logistics Agency facilities.

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To my wife and children.

Acknowledgements

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James R. Hanford

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EFFECTS OF CONTOURED PALLET USAGE ON CONTRACT AIRLIFT EFFICIENCY

I. Introduction

The United States Air Force (USAF) operates in a global environment that necessitates the transportation of various cargo and personnel around the world. Sometimes these moves are based on a standing schedule and sometimes these moves are planned at the last minute, but whatever is validated must move to the theater according to the schedule set by the chain of command.

The United States Transportation Command (USTRANSCOM) is the Distribution Process Owner (DPO) and the functional command that manages nearly all large logistics moves for the Department of Defense (DoD). The aerial portion of these moves is executed by the USAF's Air Mobility Command (AMC). When making decisions on how to execute air transport, AMC must always weigh both effectiveness of the mission as well as efficiency of the process. Here the military differs from the private sector in that effectiveness is always the first priority for military transportation as the ultimate mission is to get bullets and beans to the war fighters in the theater of operations. This is not always true for the private sector as their ultimate purpose is making a profit, which requires a balance of effectiveness and efficiency. As with all other endeavors, in this pursuit of what this author dubs, "effectiveness first, efficiency always" there are opportunities to improve both effectiveness and efficiency that are missed because the wrong metric is used or, during a change in process, the emphasis is placed on the wrong area, ultimately hurting efficiency without a boost to effectiveness.

At the direction of the USTRANSCOM, AMC contracts 20% of the cargo carried by civilian carriers to those who are contoured-cargo carriers (Anderson, 2010). Recently, AMC has noticed a disturbing trend of cancelling missions scheduled against these contoured carriers. This is of particular concern because of the steep cancellation fees charged by the carriers. In today's economy and with fierce competition for budgetary dollars, AMC cannot afford to throw money away in such a fashion. Building all pallets to contoured dimensions, however, is also wasteful as a contoured pallet has empty space that could otherwise be filled and thus leaves cargo space unutilized when moved on a non-contoured carrier.

AMC faces the problem of how to build enough pallets to fully utilize civilian contoured airlift but not so many that it reduces the efficiency of the remainder of the airlift fleet, both civilian and military.

Numerous papers have been written seeking to improve the way air-based supply chains are managed. Looking specifically at airlift ops, researchers have examined a heuristic approach to scheduling (Kopp, 2004) as well as complex, non-linear modeling of optimizing the types of pallets built for hub-and-spoke systems (Yan, et al, 2006).

Additionally, Major Myers Gray wrote a paper specifically focusing on the effects of raising pallet-build heights from 72 inches to 96 inches (Gray, 2010). This paper seeks to examine the effects on efficiency in the allocation of number of full-cubed pallets versus contoured pallets built for movement to the theater of operations from the Continental United States of America (CONUS). Specifically this paper examines the effect that the DoD’s push to increase efficiency by maximizing the number of pallets that are built to a full-cube to a maximum height rather than a more adaptable mix of full-cube and contoured pallets has actually had on total cargo space scheduled vs. cargo space used as well as the cost of this disparity. This researcher examined all Boeing 747 and MD-11 missions from Dover Air Force Base, Delaware to Incerlik, Turkey and Bagram, Afghanistan. This information was obtained from AMC’s 618th Tanker Airlift Control Center Air Operations Center (TACC) through the Global Air Transportation Execution System (GATES). The research focused on two questions.

(1) How has maximizing the number of pallets built to full-cube standards affected the availability of commercial lift capability contracted by the DoD?

(2) What inefficiencies or efficiencies will be generated by placing additional contoured pallets on standard carriers?

(3) Is reducing the amount of commercial, contoured airlift a statistically better and feasible solution?

This paper examines a review of current literature related to this subject, the methodology describing how the research evaluated the data, the results of that analysis, conclusions, and finally areas are suggested for further study.

II. Literature Review

This section begins with a short look at the Civil Reserve Air Fleet (CRAF), its evolution and its current relationship with USTRANSCOM and AMC. It then discusses the capabilities and usage of the two civilian aircraft most used to transport DoD cargo, the Boeing 747 (B-747) and McDonnell Douglass MD-11. Finally, it concludes with an examination of the factors that go into USTRANSCOM and AMC in choosing what aircraft to assign to contracted lift.

Civil Reserve Air Fleet

In examining the airlift capabilities of the DoD, the focus must not be entirely on internal military airlift capability (called “organic”), but rather on the combined capability of organic and contracted lift. The DoD contracts lift from various commercial entities that have US-flagged air fleets. The primary avenue of access to these carriers is through the CRAF program.

The civilian airline industry’s history as an unofficial partner with the United States Military stretches back to civilian carriers voluntarily operating in the Pacific theater during World War II (Crackel, 1998). In 1947, Thomas K. Finletter, a future Secretary of Defense, was appointed by President Truman to chair his “Air Policy Committee,” later known as the Finletter Commission (Futrell, 1989). This commission examined the growth of both the DoD and State Department alongside growing requirements of the Cold War and expanding commercial businesses, including airlines. It postulated that national security would benefit from keeping commercial airlines as a viable source of airlift (Donovan, 2011). After the government commandeered aircraft for the Berlin Airlift in 1948, it was further established that there should be a more formal process for using commercial airlift for DoD needs, something with which the airlines readily agreed (Donovan, 2011). President Truman signed an executive order in 1951 that outlined a more formal relationship between civilian carriers and the DoD and established the CRAF program.

Execution of the CRAF in contingency conditions is in three stages (labeled I, II and III), varying from a regional crisis to a major theater war to an event requiring national mobilization (AFTAS, 2008). The CRAF is so critical to national security interests that DoD planners count on CRAF aircraft to move 90% of all passengers and 40% of all cargo in the event of full activation (GAO, 2009). To date the CRAF has only been activated twice. The first activation was during the 1st Gulf War, with stage I being activated on 17 Aug 1990 and Stage II being activated on 17 Jan 1991. This activation saw 110 aircraft fly 5,460 missions moving over 700,000 troops and about 230 tons of cargo (Donovan, 2011). The second activation was in 2003 during Operation IRAQI FREEDOM. This was a stage I activation.

From these humble beginnings the CRAF has grown to be a critical partner with AMC, pledging 1,213 aircraft to the program in 2011. Of these aircraft, air carriers have committed 195 B-747 aircraft and 98 MD-11 aircraft (AF Form 312, 2011). Of these 195 B-747s, 113 are contributed toward CRAFs cargo needs, as are 83 of the 98 MD-11s. The contribution of CRAF to national security cannot be underestimated as it gives the DoD wartime access to airplanes it did not have to buy or maintain in peacetime. General Duncan McNabb testified to the US Congress that the CRAF program has resulted in a cumulative cost avoidance of “between $43 and $128 billion” in 2009 dollars (McNabb, 2009). In return for this access, the DoD gives CRAF participants access to peacetime sources of revenue.

In 1960 the Reed Committee Report made a recommendation that in return for providing this service to the DoD, a process should be established that awarded peacetime business to carriers based on a variety of items, primarily contribution to the CRAF (AFTAS, 2008). Soon after the mobility value (MV) point system was established in 1962. This system awards MV points to carriers based on how many aircraft they commit of what type and to what stage of CRAF. The points are based on a baseline using the B-747 as 1 MV point. Bonuses are given based on what stages are committed to (see Figure 1). Commercial business (contracted cargo and passenger movement) are then offered to participating carriers based on their share of MV points. This is a lucrative source of revenue for many carriers, valued at $2.6 billion in fiscal year 2007.

Mobility Value Examples

Aircraft	Aircraft MV	MV Point Base	Stage	Bonus	Total MV Points
B-747-100	1.0	10	I	100%	**20**
B-747-100	1.0	10	I	100%	**20**
B-747-100	1.0	10	II	0%	10
B-747-100	1.0	10	II	0%	10
B-747-100	1.0	10	II	0%	10
B-747-100	1.0		III	0%	10
TOTAL					**80**

Figure 1. Example Calculation of MV points(AFTAS, 2008)

Because the size of carriers varies from the largest commercial airliners to the smallest contract carriers, in 1992 many companies joined together to form teams (AFTAS, 2008). These teams pool their MV points together which are then distributed to members by the team leader, who takes a management fee for this service. Teaming arrangements are beneficial to many of the small carriers who gain access to more missions than their MV points alone would allow. This is because many of the large carriers, such as FedEx contribute to the CRAF program but have little interest in peacetime missions as their fleet is near-fully utilized and thus pass their large share of MV points to their teammates (AFTAS, 2008).

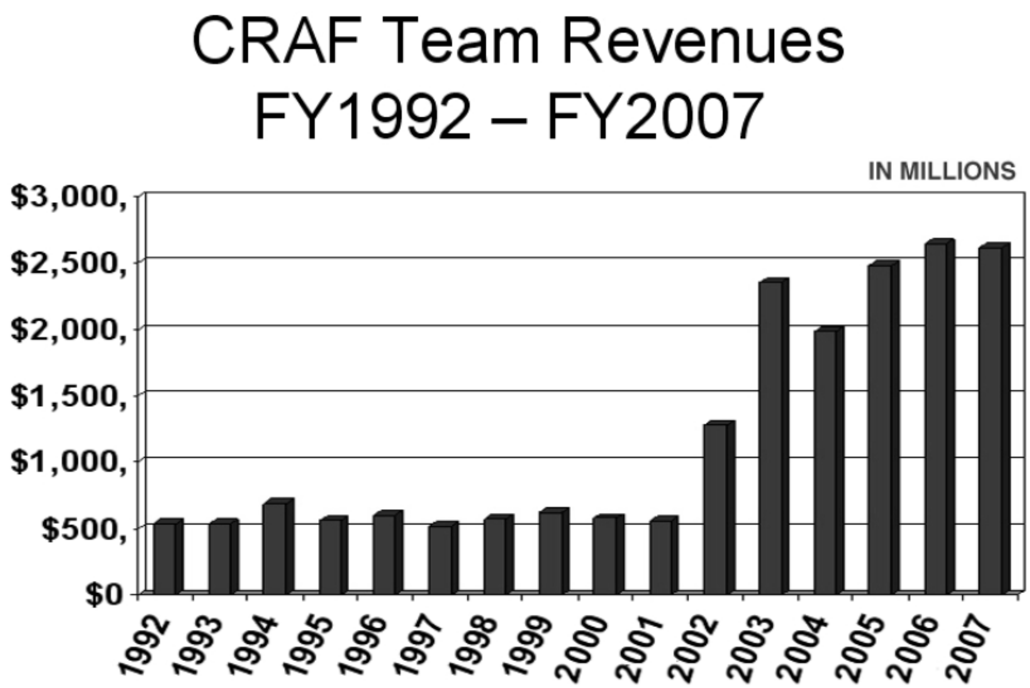

Figure 2. CRAF team revenues (AFTAS, 2008)

The value of business available in contracted missions has grown a great deal since September 11th, 2001 (see Figure 2). As the pie has increased, so has the interest in securing pieces. Recent discussions have questioned teaming arrangements and segregation of cargo and passenger MV points. Teaming has faced criticism both as a way that some carriers get more than their fair share of peacetime missions because of their teams as well as internal team conflicts, such as the recent bankruptcy of ATA Airlines resulting from what they claim were unfair administration practices of their team lead, FedEx.

As the economy changes and the relationship between the CRAF and AMC will further develop with a CRAF that requires a robust peacetime cargo charter program that is an appropriate incentive for participation (Graham, 2003) and an AMC forced to ensure that their utilization of CRAF contracts are as cost-effective as possible.

Capabilities of the Boeing 747

Figure 3. Boeing 747-400 freighter (AMCPAM24-2V2, 2001)

One of the most ubiquitous airframes amongst long-haul civilian cargo carriers is the Boeing 747. There are several variants of the B-747, including those outfitted for cargo (B-747 100F, 200F and 400F). The B-747 can carry between 33 and 37 pallets on its main deck and has a capacity to carry 9 smaller pallets in its lower belly section (AFPAM24-2V2, 2001). AMC recognizes the Allowable Cargo Load (ACL) as 106.5 short tons for the B-747-100, 120 for the 200 and 129.7 for the 400. In order to maximize range and streamline planning, USTRANSCOM contracts B-747 missions at 90 tons, using the 100 models as a baseline (Mintzlaff, 2007). Some 200 and 400 models have nose doors to load larger cargo and pallets in a train (AFPAM24-2V2, 2001). However, since no 100 models and not all 200 and 400 models have this capability B-747 loads are typically planned around this limiting factor and all cargo is built to enter the side doors. Boeing is also currently producing 800 models, which have a better range and are more fuel efficient and cheaper to operate. However, these models are still in production with none yet delivered to any carriers.

The B-747 can carry pallets that weigh up to 12,500 lbs (400) or 10,000 (100 and 200). The maximum limit in all variants is near the center of the aircraft and decreases as the pallet position nears the nose or tail. All pallet positions on the main deck can hold a pallet that is standard width and length and with a height of at least 96 inches, with a maximum height of 118 inches in some locations, if the pallet is contoured (AFPAM 24-2V2, 2001).

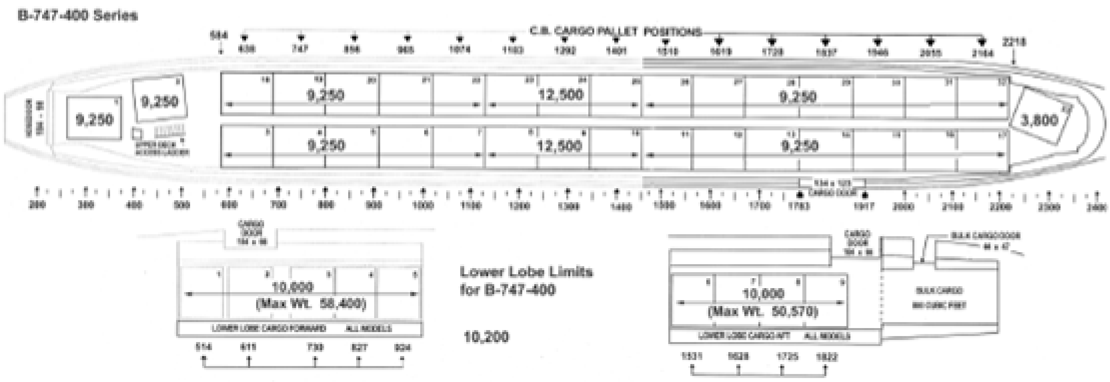

Figure 4. B-747-400 in 38 pallet configuration (AFPAM24-2V2, 2001)

Capabilities of the McDonnell Douglas MD-11

Figure 5. MD-11 freighter (AFPAM24-2V8, 2001)

The MD-11 is the other principal aircraft used for long-haul cargo operations by carriers. There are two primary variants of the MD-11, the MD-11F and the MD-11CF.

Both can carry 35 pallets on the main deck and have a forward lower-deck capacity of six additional pallets and a rear lower-deck capacity of 5 or 6 pallets, depending on the particular aircraft's configuration (AFPAM24-2V2, 2001). AMC recognizes the Allowable Cargo Load (ACL) as 96 short tons for the MD-11F and 89 tons for the MD-11CF. However, unlike the B-747 whose effective range (of the 100 and 200 models) does not differ, the effective range of the MD-11CF is 4,500 nautical miles compared to the 3,500 of the MD-11F. As with the B-747, USTRANSCOM plans contracting of MD-11s at a maximum of 89 tons. No MD-11s are equipped with a nose door so they are typically unable to carry pallets that are married on train together.

MD-11s carry pallets that weigh up to 10,000 pounds. Again, the maximum weight limit is near the center of the aircraft and decreases approaching the nose and tail. All pallet positions on the main deck must be contoured in order to fit inside the aircraft. Contour shapes are shown in Figure 6 below.

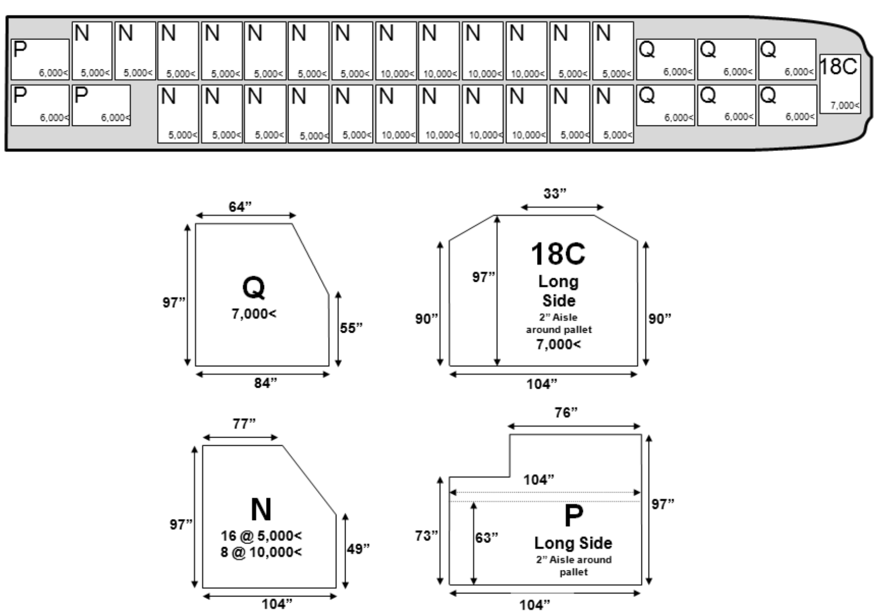

Figure 6. MD-11 main deck pallet capacity and pallet profiles (TACC planning guide)

USTRANSCOM's Recent Initiatives to Improve Cargo Flow

During the 1st Gulf War the DoD learned many lessons regarding the utilization of distribution networks to move cargo to the warfighter. The capacity of the transportation arm of logistics far outstretched the tracking arm. This resulted in host of cargo containers arriving in theater without any clue of what was in them or what their final destination was. Warfighters in theater would put in duplicate requisitions when their cargo was late, which only resulted in superfluous amounts of cargo arriving in the theater, which further added to the chaos (Jackson, 2007). This resulted in the now famous "Iron Mountain" of more than 40,000 cargo containers that piled up in theater, many of which were never opened.

In the following years the DoD strove to improve the logistics system and avoid another "Iron Mountain." While the creation of another mountain was avoided during the initial phases of Operations ENDURING FREEDOM and IRAQI FREEDOM there were still many delays in the system. Military leadership saw numerous opportunities for improvement in the logistics process to move cargo to the combat theater. In 2004 the Secretary of Defense undertook another study to see how the process could further be improved. In their report, the Government Accountability Office noted that volume at DoD distribution centers was so great that pallets were built mixed and sent out as fast as the centers could handle (GAO, 2005). This contrasted with the peacetime practice of building "pure" pallets, those that were made up entirely of cargo destined for one unit or final destination. While sending mixed pallets resulted in a large amount of needed equipment arriving quickly in theater, the Aerial Ports of Debarkation (APOD) found that they had to perform the labor-intensive and time-consuming process of breaking down pallets and redistributing the contents according to their final destination/unit.

In 2003 a pure pallet process was begun at the Defense Logistics Agency's (DLA) Susquehanna facility, which began to build pallets for single unit/destinations. This resulted in a facility hold time increase (e.g., from 48 to 120 hours for Army cargo) (Mongold, 2006). The idea being that accepting a longer hold time at the DLA would result in a shorter processing time in theater and overall greater velocity of requisitioned goods to the warfighter. After favorable initial observations, the program was expanded to include the aerial ports at Dover and Charleston, thus allowing DLA facilities to ship mixed pallets to aerial ports where military porters would break down the cargo and then rebuild it as pure pallets. Initial perceptions were that this pure pallet process did indeed improve the distribution process. Numerous studies also evaluated this process and validated its contribution to system effectiveness and efficiency (Dye, 2006 and Mongold, 2006).

Even with the improvements seen from the pure pallet process, USTRANSCOM still saw opportunities to improve the flow of cargo to overseas locations, particularly CENTCOM. Recently AMC and USTRANSCOM have moved forward with their Next Generation Cargo Capability (NGCC) initiative. The ultimate goal of the NGCC is to improve utilization of both pallet and aircraft utilization for inter-theater airlift, particularly concerning commercial wide-body airlift provided by B-747s and MD-11s (Finney, 2010).

The NGCC consists of several different measures. However, for the purposes of this research the one of primary concern is the examination of cargo capacity utilized by both weight and cube. The goal here is to use aircraft to the maximum amount of their capabilities in both volume and weight of cargo carried. Recent metrics indicate that 54% of pallets built at the aerial port were “capped” (i.e. installing netting or other restraint and terminating further building) after one day, even if the pallet was not built to full capacity. This was often done in order to move the pallet quickly and reduce port hold time, which is a monitored metric. The same examination also showed that ever day the pallet remained uncapped it would accumulate 5% more cargo, demonstrating pallets were being capped before it was necessarily the best time to do so (Busler, 2010).

In order to work to achieve higher utilization rates, ports were directed to build larger, heavier pallets at APOEs. As it takes longer to both gather the cargo at the APOE and to build the pallet, this process is a trade-off of velocity for efficient utilization (Finney, 2010). Much like the pure-pallet process, building these larger pallets also lessens the workload of aerial ports in theater as they are moving the same amount of cargo but on fewer pallets which requires less handling.

While not yet in widespread use, it should be noted that during “proof-of-principle” testing at Dover AFB AMC was able to improve airlift utilization by 11.7%, as measured by both cube or weight utilization (Busler, 2010). It should be noted that this process is still ongoing and that the data used in this research was taken prior to the NGCC “proof-of-principle” test implementation.

Contrasting DoD vs. Civilian Cargo Airlift

While the DoD and civilian companies both use extensive cargo airlift, a brief examination at some of the differences should be understood when looking at AMC’s utilization of civilian contracted lift. A paper from the Wharton Business School notes that military and civilian supply chain networks cannot be fully compared. This is particularly true because an inefficient or ineffective supply chain in the civilian world will result in lost profits whereas the same problems in the military can result in the deaths of soldiers (Wharton, 2003). That being said, there are still many aspects of aerial transportation that can be compared and contrasted between the two areas.

The obvious civilian carrier comparable to AMC is FedEx Express. Both operate large air fleets. FedEx's long haul fleet is made up almost entirely of DC-10s and MD-11s (134 of 140 total aircraft), which have the previously mentioned limitations of contour requirements on pallets (FedEx, 2010). FedEx capitalizes on this configuration by utilizing AMJ cargo containers, which are easily loaded with loose cargo and shaped to meet contour requirements of DC-10s and MD-11s (Yan, et al., 2006). FedEx Express typically does not move rolling stock or large bulk goods and the average weight per package in 2010 was just over 3 pounds (FedEx, 2010). Conversely, AMC moves items that weigh much more on average and vary in volume and size much more than packages sent through FedEx. Therefore AMC's strategic inter-theater (i.e. long-haul) air fleet is far more flexible than FedEx's as the C-17 and C-5 can carry virtually any cargo that can be moved by air. Rolling stock and hand-carried cargo can be loaded directly on the cargo floor, while virtually all palletized cargo is loaded on the standard 463L military pallet. This ensures just about anything can be loaded on an AMC aircraft as well as meet the requirements of the handling capabilities of aerial ports, many of which are limited due to their location in combat theaters.

FedEx and AMC both use variations of hub and spoke systems. Like AMC, FedEx has processes in place that analyze the utility of building pure pallets at origin

APOE or by breaking the containers down and rebuilding containers by APOD while at the hub. Again, this decision is highly dependent on the time and resources available at each location. The key difference here is that FedEx Express' model is one that guarantees next day delivery, making time of the essence, and that hub and final destinations don not have the combat environment as a concerning factor. Though beyond the scope of this paper, see Yan for a model of this decision process centered on FedEx's Pacific operations (Yan, et al, 2006).

USTRANSCOM's Decision Factors in Use of Contoured Airlift

In 2007, some of the smaller carriers that utilized MD-11s and DC-10s (another aircraft requiring contoured pallets) informed the USTRANSCOM commander that they felt that while contributing airframes to CRAF they were not receiving an equitable deal in contracted peacetime missions. This outcry from so many CRAF participants drove USTRANSCOM to review the way they allocated cargo airlift missions to their civilian partners.

Historically, AMC has preferred to use B-747s to transport cargo as it can carry more pallets and tonnage over a single mission, which increases velocity of cargo through a port. From an operational standpoint this reduces pressure on max-on-ground (MOG) numbers and enables aerial ports to operate more efficiently. Financially the B-747 is also considered a better value compared with MD-11s in both cost per ton and cost per pallet (Mintzlaff, 2007).

These numbers have been called into question by numerous carriers who utilize contoured lift. They have pointed out that MD-11s are newer than most B-747s and far more fuel efficient. They also note that the average crew size is smaller and has a lower operating cost than older B-747s (Newberry, 2007). Other research has shown that USTRANSCOM's practice of contracting out missions based on a general cost-plus approach has skewed the total costs of the carriers and stifled incentives for carriers to upgrade their fleets to more modern, more efficient aircraft (AFTAS, 2008). In other words, USTANSCOM pays the same rate for cargo movement if a carrier moves it on a B-747-100 as if it was a B-747-400, all while not planning to take advantage of the additional cargo capacity of the newer aircraft. This gives little incentive for carriers to use B-747-400s on DoD missions but rather to save them for commercial jobs where efficiency is much more valuable (Smith, 2009). Likewise, it encourages carriers to keep older jets since there is still a cost-effective use for them. If the DoD incentivized fuel efficiency then carriers would be pressured to upgrade their fleets to more efficient aircraft. Contoured carriers complain that this practice biases costs against their fleet since the MD-11 is more efficient on a pure non-capitalized cost per ton-mile (Global Aviation Holdings, 2010).

Despite these claims, AMC still views the B-747 as the superior platform based on greater overall costs of utilizing more MD-11s and the operational costs of using more tails to carry the same amount of cargo. However, even with the B-747 being currently seen by AMC as a superior platform, USTRANSCOM must also consider the CRAF program's primary mission – the partnership with civilian carriers to ensure a sufficient supply of airlift assets in case of CRAF activation. In order to guarantee robust participation in CRAF, USTRANSCOM must ensure that carriers feel that participating is worthwhile to them and fairly compensates them for the business risk they assume by pledging aircraft to the program (McNabb, 2009). Currently many of the contoured carriers feel that USTRANSCOM awards too much business to B-747 carriers. In congressional testimony Fred Smith, Chief Executive Officer of FedEx, pointed out that less than half of all cargo aircraft in CRAF are B-747s yet they receive 80% of the long-haul business (Smith, 2009).

After further consideration USTRANSCOM determined that they considered the B-747 more cost effective, but must also take into account that the CRAF program must “include all carriers” and promote participation by the same (USTC, 2007). It was also determined that increasing the number of contoured-pallet aircraft would not significantly impact operations. With this in mind General Norton Schwartz, the then Commander of USTRANSCOM decided that a goal would be set to offer 20% of all CRAF cargo to non-747 carriers (USTC, 2007).

Upon this decision, AMC began to contract with more MD-11 carriers to move cargo. However, due in large part to other initiatives that promote the building of full-cubed pallets, many MD-11 missions are canceled due to lack of available contoured cargo, even when several hundred tons of cargo are available at the port, though not in contoured configurations (Anderson, 2010). These cancelation costs run into six figures per cancellation, detracting the cost effectiveness of the entire program. These cancellation fees are driving a re-examination of the decision to offer 20% of missions to cargo carrier and what steps could be taken to reduce cancellations.

III. Methodology

Scope

AMC moves tens of thousands missions around the globe each year. To limit the scope of examining this global flow, this research focused solely on pallets leaving Dover AFB, DE and travelling on aircraft destined for Incirlik AB, Turkey. This selection of data gives the best cross section of cargo originating at Dover that typically travels on commercially contracted airlift. Data was limited to missions flown by Boeing 747s (B-747) and MD-11s, the two types of commercial carriers frequently utilized at Dover. Organic airlift was excluded since it is often used to carry cargo that MD-11s could not carry anyway (e.g. pallet trains, outsized cargo, etc).

Assumptions and Limitations

This paper does not examine the process whereby the Defense Logistics Agency (DLA) builds pallets and assumes that DLA is capable of building standard pallets of cargo out of all cargo available. Because the GATES database does not distinguish between different types of pallets (married, outsized and oversized) the research assumed that all cargo could be loaded onto standard pallets.

It is assumed that all pallets in question are the standard military 463L pallet, measuring 108 inches by 88 inches. Actual footprint of this pallet requires a 2-inch aisle way along each border, resulting in a usable surface area of 104 inches by 84 inches.

GATES data gives dimensional measurements for each pallet as a whole but does not give exact dimensions. That is that GATES tracks height, weight and cube (i.e.

volume) measurements but it does not provide the exact details on the contours of the pallet (how high it is built to in various spots on the pallet), only the type of build that matches planning guides. It is assumed that all B-747 pallets are loaded as a cube and MD-11 pallets are loaded up to the height given while maximizing any contour that would be required to travel on an MD-11. That is, even though a pallet could consist of boxes that were stacked to 54” on one half of the pallet and stacked to only 38” on the other half, this research treats anything in GATES as loaded amongst the entire surface of the pallet, up to the height given. Additionally any pallet labeled as contour-compatible was assumed to be at the height given and perfectly contoured to fit the profile.

Because of the limitation of the GATES database, it is impossible to tell the actual cargo on the pallets in the historical data. This required the researcher to make certain assumptions on the nature of each pallet’s contents. The researcher assumed that the density on each pallet was constant throughout that pallet. Likewise, the assumption was made that any cargo on a pallet could be redistributed as needed to any other pallet.

In order to make the MD-11 calculations a little more conservative, the contoured pallet-size that makes up the majority of space on a MD-11 was used as a standard pallet for each position on the MD-11. That, is, the researcher assumed that each position would hold the equivalent of a pallet with the same dimension as that one labeled “N” in Figure 6. As this shape of pallet makes up over two thirds of the pallets and is roughly the same in volume as the other pallets, this was considered a good assumption that simplified calculations yet maintained accuracy. In order to keep the modeling conservative, new pallet builds were assumed to be made with all right angles, reducing the available volume for adjusted pallets.

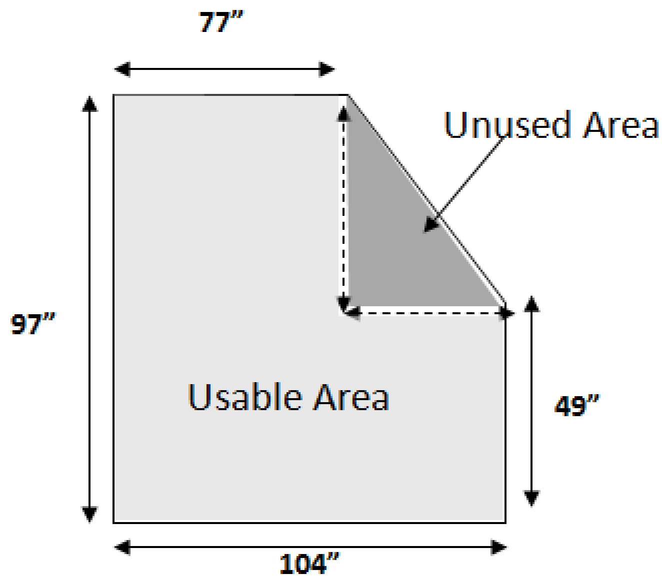

Figure 7. Depiction of contoured pallet with right angle gradient

In addition to maximum weights per pallet, both B-747s and MD-11s have maximum weights for certain zones in their holds. Because it is impossible to tell from GATES where each pallet was loaded, this limitation is disregarded and instead AMC’s max ACL for each plane is used.

Capacity of B-747s and MD-11s vary based on their model and configuration, particularly with regard to the B-747s. For this analysis B-747s were considered to carry 42 pallets and MD-11s 46. Both these numbers assume the main deck is filled to capacity with a portion of the belly pallet positions going empty.

It was assumed that there was no hazardous cargo as some types of hazardous cargo cannot be mixed, which would negate the possibility of combining any pallet with any other pallet.

Data

Historical data concerning cargo pallets was pulled from GATES for the 2010 fiscal year (FY2010). This data consisted of the type of aircraft transporting the pallet, the mission numbers and dates, the flight routing (i.e. en-route fields visited), the height and weight of each pallet, total planned and actual weights of cargo on each aircraft, the planned and actual pallets carried by each aircraft, and pallet identification numbers. The data was organized in an excel spreadsheet with each line consisting of information for each pallet.

The data showed that AMC flew just over 56,000 pallets of cargo out of Dover AFB. Of these, 26,516 pallets out of Dover in FY 2010 were flown via B-747 or MD-11 to Incerlik AB, Turkey, for further distribution.

Most data from GATES can be deemed reliable save for the "pallet type." More than half the pallets were typed as "pallet with propeller." As it is doubtful that over 50% of the pallets sent to Incerlik AB had a propeller on it this label can be considered erroneous. This did not affect data calculations other than to note that it is good information to have which pallets contain propellers as their contents certainly cannot be rearranged.

Data from GATES was initially analyzed to see current utilization rates and build styles originating from the various sources of palletized cargo, particularly from those pallets built at Dover AFB and DLA's Susquehanna facility. These results will be discussed in Chapter IV.

Modeling methodology

The researcher proceeded to construct four different models using Microsoft Excel in order to both better understand the nature of the cargo being moved and determine if opportunities existed to take advantage of increased MD-11 airlift. Each model had different conditions and additional assumptions built into them, ranging from broad assumptions in Model 1 to the much more restrictive Model 4.

Key pieces of original data from GATES were time and date of the mission departing Dover AFB, pallet identification codes, APODs for each pallet, and their height and weight. From this data the researcher was able to extrapolate potential cargo volumes and densities. This data was then used to model the reconstruction of cargo on the pallets in order to transform them into contour-compatible pallets.

As it is unrealistic to assume that any cargo for the given fiscal year was available at any point in the year, the data was divided into 52 periods consisting of one week each. These weeks started on 1 October 2009 and went through 30 September 2010 (i.e. FY2010). This does have the disadvantage of assuming that all cargo that transited Dover AFB in a week was available on the first day of the week. However, utilization of port times from GATES was too cumbersome for this study and the researcher concluded that while not all cargo for the week would be available on Day 1 of that week, at any given time cargo is available in the port and moves through in such a way that it can be considered in the build process, if not immediately available. Likewise cargo that was in the yard on day 7 of the previous week would still be at Dover AFB and this assumption was a fair guess at the movement of cargo through the APOE.

Models 1 through 3 are considered only illustrative in nature and no analysis as to how many missions, using what type of aircraft, would best transport the cargo. Thus there was no financial analysis done on these models. Instead mission and financial calculations were only done on Model 4 as it is the most restrictive and realistic of the models.

Model 1 simply took every pallet that transited from Dover AFB to Incerlik AB during the year and reformed them into contour-compatible pallets. This required assuming that not only all cargo could be reconfigured in any way possible on pallets, but that densities and shapes were uniform. In other words, this model treats cargo as if it were clay, including pallets expressly labeled as rolling stock, which obviously cannot be configured in this manner. While unrealistic, this model does show the relation between how much volume capacity was available on the lift contracted for the time period vs. how much was utilized and how much could have been used with a greater percentage of MD-11 lift. This model also reconfigures all cargo originally moved on MD-11s between Dover AFB and Incerlik AB to make more efficient use of its pallet positions. The results from this data were taken as informational only.

For Model 2 the researcher removed the MD-11 data from the mixture. Again, this is very conservative as there is no indication that pallets moved this way were explicitly built to travel on a MD-11 or to maximize utilization of pallet space. However, for the purpose of this research, this assumption allowed the data to be scoped in a way to make it more manageable while maintaining the purpose of the research. Model 2 also removes any pallets specifically identified in GATES in a way that makes it clear that reconfiguration is not possible (e.g. rolling stock, pallet trains and ISUs). Again, Model 2 was built for informational purposes only.

Model 3 restricts the reconfiguring of pallets further. This model begins to distinguish between what is on the pallet in relation to densities and builds. This model does not tamper with any pallet built to 49 inches or lower in height. 49 inches was chosen as that is the height at which the most restrictive contours begin, so any pallet that is 49 inches or shorter will fit on a MD-11. Additionally, looking at the data empirically many, but not all, pallets built to shorter heights had a heavier density making them poor candidates for reconfiguration. Additionally, in this model any pallet with a density of more than 15 pounds per cubic foot was not reconfigured. 12 pounds per cubic foot was chosen as it is the density that gives a maximum pallet weight for a contour-compatible pallet. Finally, Model 3 maintains the current USTRANSCOM pure pallet initiative and only combines pallets that are travelling to the same APOD.

Finally, Model 4 takes into account all of the restrictions of Model 3 as well as adding in one more important qualification. Model 4 only reconfigures pallets amongst the same locations where they were built. That is, pallets built at the DLA facility in Susquehanna are only mixed with other pallets from Susquehanna. This keeps the pure pallet function at both origin and destination so as to not add additional work on the aerial porters working at the APOE. This model was created and then put through further analysis to determine the optimum usage of aircraft types to move the cargo to theater, followed by a look at the cost effectiveness.

IV. Results and Analysis

This chapter opens with a brief discussion at what the aggregate data relates concerning overall efficiency of use on contract lift from Dover AFB to Incerlik AB. It then discusses each model and provides some results. Finally, it concludes with a look at the financial implications of Model 4 and potential savings.

General Data Analysis

Data was first compiled and analysis to both look at the total cargo moved on B-747s and MD-11s from Dover AFB to Incerlik AB, Turkey. This gave the researcher a broad view over the efficiencies in using these aircraft in moving cargo. Considering that the B-747s are planned to move 42 pallets and 90 short tons, the researcher was able to analyze the utilization rates for this aircraft. Additionally, with these constraints, the total volume able to be carried by a B-747, for planning purposes, is 18,745.86 cubic feet of cargo.

The researcher observed that in terms of pallet-space utilization the B-747 was quite efficient, using 97% of pallet positions. This was less true of weight and volume utilization at 84% and 74%, respectively. One would expect volume utilization and weight utilization to trade off as cargo with higher densities would maximize weight limitations while underutilizing volume limitations and low-density cargo would do the opposite. However, the data shows that both volume and weight utilization rates are fairly consistent at the rates above.

This analysis on the MD-11 shows a similar consistency of usage. However, MD-11s were used at only 80% of pallet capacity, 77% of volume capacity and 60% of weight capacity. There is no clear indication as to why these numbers are what they are, but lack of contoured pallets as a whole probably contribute to the lower pallet position utilization, driving down the efficiency of MD-11 use.

Aircraft	Pallet Utilization	Volume Utilization	Weight Utilization
B-747	97%	74%	84%
MD-11	80%	77%	60%

Table 1. Utilization rates for B-747 and MD-11

Model 1 Results

While Model 1 uses assumptions that just are not practical in the real world, but are nevertheless instructive to compare efficiencies of actual performance with idealized performance. However, it does tell the researcher that there is a maximum 27% of potential savings (in terms of number of pallets) to be achieved if all cargo was reconfigured to contoured pallets. It does not explain how much of that is realizable and how much is not.

Model 1	Original	New
Missions required	660	409
Pallets required	22002	17147
Average Pallet Volume	329.10	422.28
Average Pallet Weight	3673.51	4713.62
Average Weight per cubic foot	11.16	11.16
Reduction in pallets	27%	

Table 2. Model 1 results

Model 2 Results

Model 2 removed all pallets originally travelling on the MD-11 from the picture. It then sorted and redistributed all pallets on the B-747s to contour compatible pallets. It did not sort any pallet marked as taking up more than one pallet position (e.g. pallet trains) or rolling stock, which made up 997 pallets on B-747s on this route. It is interesting to note that the pallet position savings are even higher in this model, but that is explained by the fact that the MD-11 data is removed, as the MD-11 pallets were more efficient in terms of volume utilization. Adding the MD-11 data back in would yield a pallet savings of 25.8%, just below that of Model 1.

Model 2	Original	New
747 missions required	528	343
single pallets	21005	13396
of total pallets	22002	14393
Average (single) pallet volume	338.69	393.03
Average (single) pallet weight	3726.05	4323.83
Average weight per cubic foot on single pallets	11	11
Reduction in pallets	31.48%	

Table 3. Model 2 results

Model 3 Results

Model 3 considered all restrictions of Model 2 as well as removing all pallets built to 49 inches or less in height from redistribution. Additionally, it maintains the pure pallet concept by only redistributing pallets between like APODs. In other words, cargo taken from a pallet destined for Al Asad AB in Iraq (3OR) will only be redistributed to another pallet destined for Al Asad AB. This step helps protect from actions that would generate additional inefficiencies downstream of the transport process in order boost measured efficiencies at the APOE. Additionally, this model took the density of cargo into account. It only redistributed cargo that had a density of less than 15 feet per cubic foot, the maximum allowed density of contoured pallets with MD-11 weight limits. Finally, the model only redistributed pallets destined for 14 different APODs (Table 4) as they made up the lion's share of the cargo on the examined route.

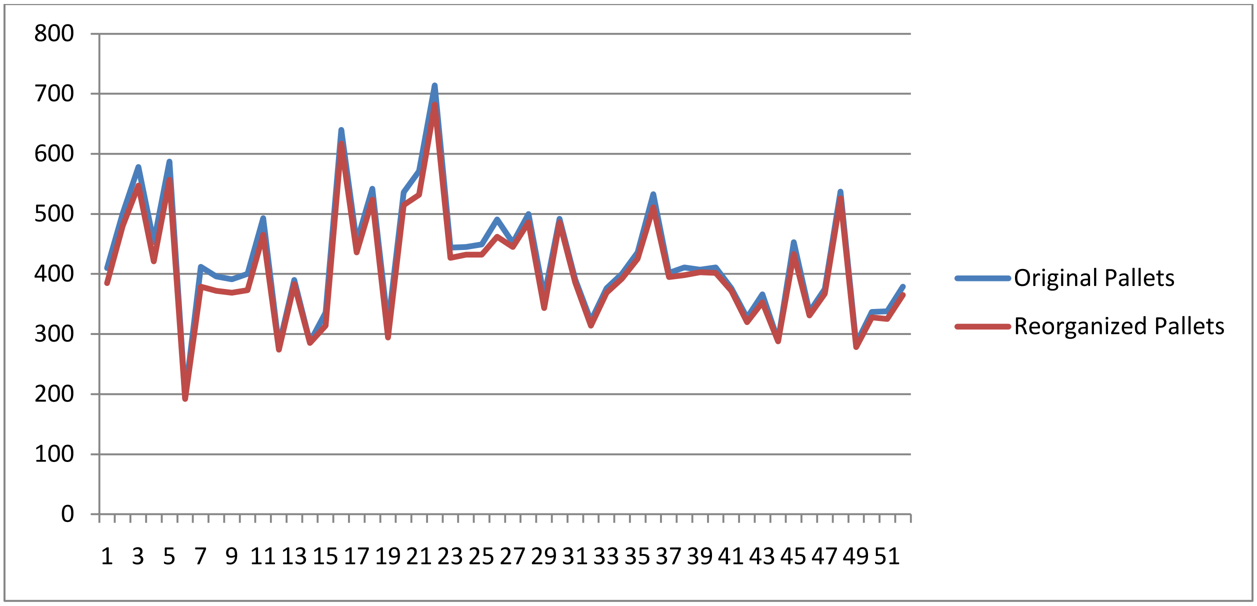

Figure 8. Number of pallets moved per week, Model 3

Additionally, the researcher notes that the model has come to the expected place where redistribution of pallets from B-747 compatible cubed pallets to smaller (in volume) contour-compatible pallets actually increases the number of pallets to move. It should be noted that this is not always true as the number of pallets destined for some APODs shrinks while at other APODs the number grows. At higher volume utilizations this increase will grown, but current volume utilization rates keep this difference low. It can also be noted that with Model 3 the number of pallets termed ineligible for redistribution rose a great amount, to 8,996 pallets from 997 pallets in Model 2.

Model 3		3OR	AZ1	BSR	KDH	KIK	O2R	O6R	O8R	OA2	OR9	OSM	SDA	TA8	TE2
Original	Eligible Pallets	154	3264	143	4107	216	465	137	104	194	1587	350	1004	786	142
	Ineligible Pallets	120	2,552	149	2,483	172	481	144	95	123	1,030	232	788	522	105
	Eligible Pallet Average Volume	365.53	377.12	362.82	393.04	400.82	385.90	386.61	372.55	382.63	381.60	401.44	369.31	384.20	381.66
	Eligible Pallet Average Weight	3,468.31	3,330.84	3,317.12	3,507.25	3,744.1	3,332.2	3,500.09	3,024.0	3,460.0	3,363.2	3,590.29	3,320.9	3,567.3	3,000.2
New	Eligible Pallets	153	2,947	146	3,870	229	459	140	107	192	1,459	362	894	736	147
	Ineligible Pallets	120	2,552	149	2,483	172	481	144	95	123	1,030	232	788	522	105
	Eligible Pallet Average Volume	357.8	417.8	344.1	418.9	359.4	385.6	372.8	356.2	380.4	411.4	383.6	406.8	405.7	361.2
	Eligible Pallet Average Weight	3,383.5	3,693.2	3,170.54	3,737.6	2,963.5	3,340.7	3,431.4	2,931.0	3,441.7	3,638.5	3,447.3	3,654	3,779.9	2,852.5
	Average Weight/Cubic Foot	9.46	8.84	9.21	8.92	8.25	8.66	9.21	8.23	9.05	8.84	8.99	8.98	9.32	7.90
	Change in Number of Pallets	0.36%	5.45%	-1.03%	3.60%	-3.35%	0.63%	-1.07%	-1.51%	0.63%	4.89%	-2.06%	6.14%	3.82%	-2.02%

Table 4. Model 3 results

Model 4 Results

Model 4 is nearly identical to Model 3 with one additional restriction. It only redistributes pallets at their origin, per the pallet identification code. That is, cargo from pallets built at DLA's Susquehanna facility is only redistributed to other pallets built at the same location. This restriction is in addition to all previous restrictions and has the added effect of reducing the amount of inefficiencies generated in the pallet building process upstream of the APOE.

Because the majority of pallets for this route are built either at the Susquehanna facility or Dover AFB itself, only those two locations were modeled. Redistributing cargo from Susquehanna increases the amount of pallets needed, which is the result expected if pallets are effectively utilizing volume available. However, redistributing cargo from pallets built at Dover decreases the pallets needed by a very large 13.3%, indicating that volume available is not utilized at Dover anywhere near what it is at Susquehanna. Table 5 shows the comparison between aggregate pallets at the two facilities for the year. However, when examining the weekly breakdown of pallet redistribution, the research shows volume utilization at Susquehanna is not only more efficiency but far more consistent than at Dover AFB. This is displayed in chart form in Figure 9.

Model 4	Susquehanna	DOV
Eligible Pallets	6,409	5,092
Reorganized Pallets	6,540	4,415
Change in pallets	2.04%	-13.30%

Table 5. Model 4 Comparison between Dover and Susquehanna

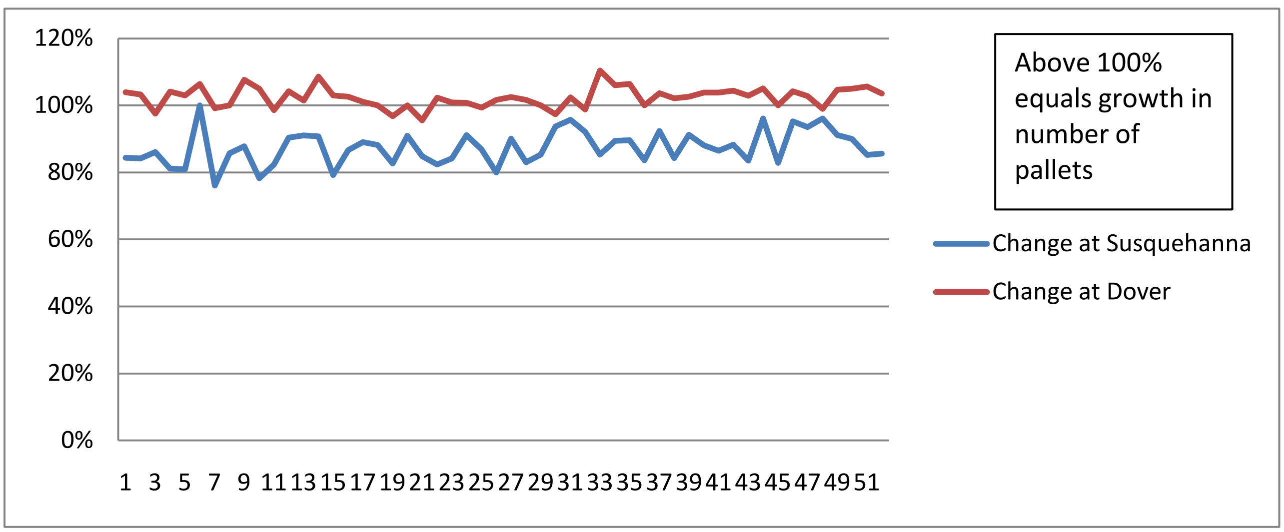

Figure 9. Change in number of pallets after reorganization

Applying Model 4 to the GATES data resulted in 11,501 pallets eligible for redistribution and 10,501 pallets that are not eligible. This is a total reduction of 2.48% of total pallets, almost all of which come from pallets built at Dover AFB. As MD-11s can carry more actual pallets, if not less weight, this new amount of pallets results in a reduction of the overall sorties required to move this cargo from Dover AFB to Incerlik AB.

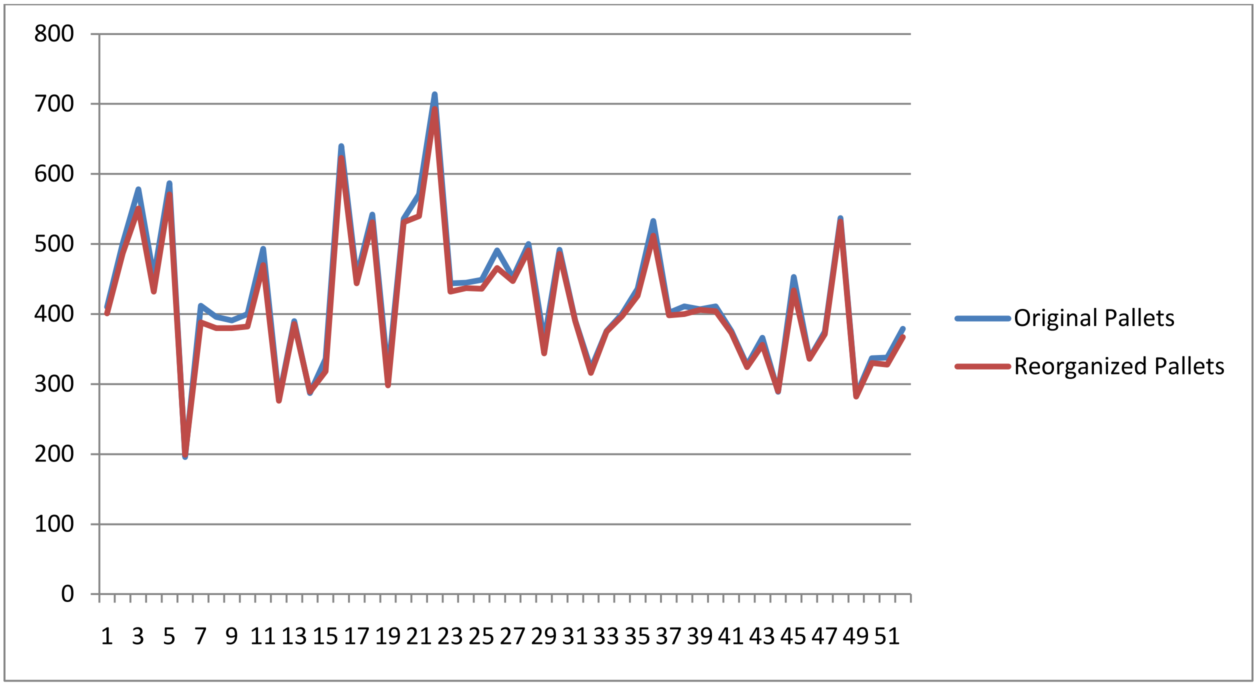

Figure 10. Number of pallets moved per week, Model 4

Model 4	Original	New
Eligible Pallets	11,501	10,955
Reorganized Pallets	10,501	10,501
Total Pallets	22,002	21,456
Change in pallets	-2.48%	

Table 6. Model 4 total pallet results

Finally, with Model 4 the researcher took the additional step of allocating the newly created pallets with airlift in order to compare the number, type and cost of missions with the original data. Even though all redistributed pallets are compatible with

MD-11s, the researcher tried to remain as close as possible to USTRANSCOM's goal to use MD-11s for 20% of all commercially contracted cargo lift.

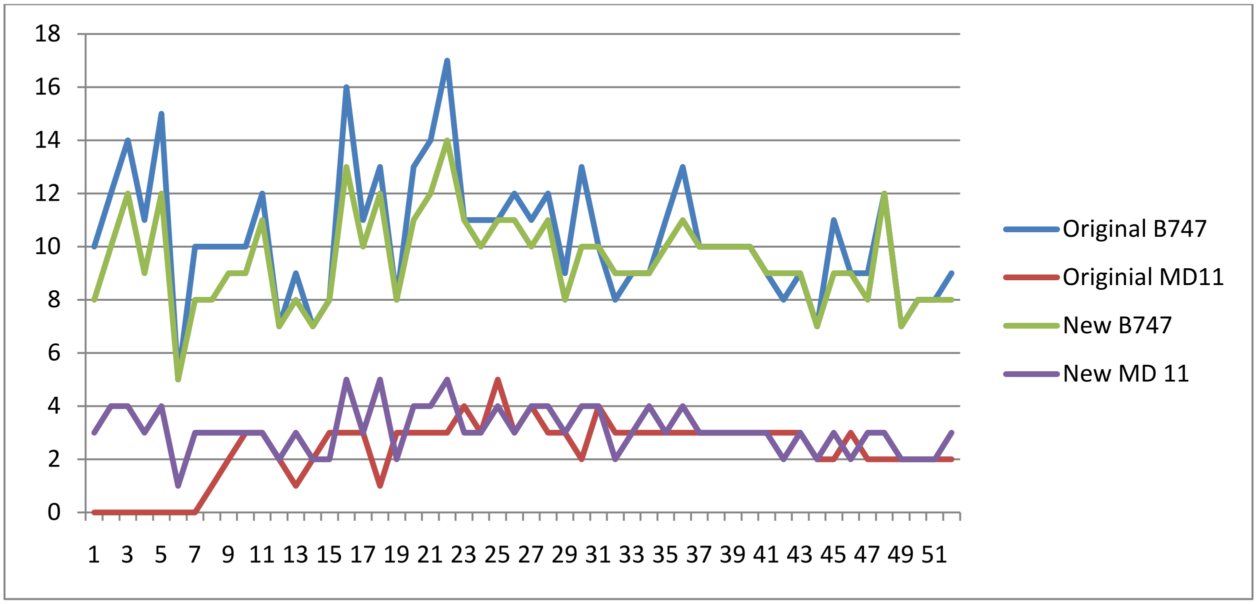

Figure 11. Weekly missions required, Model 4

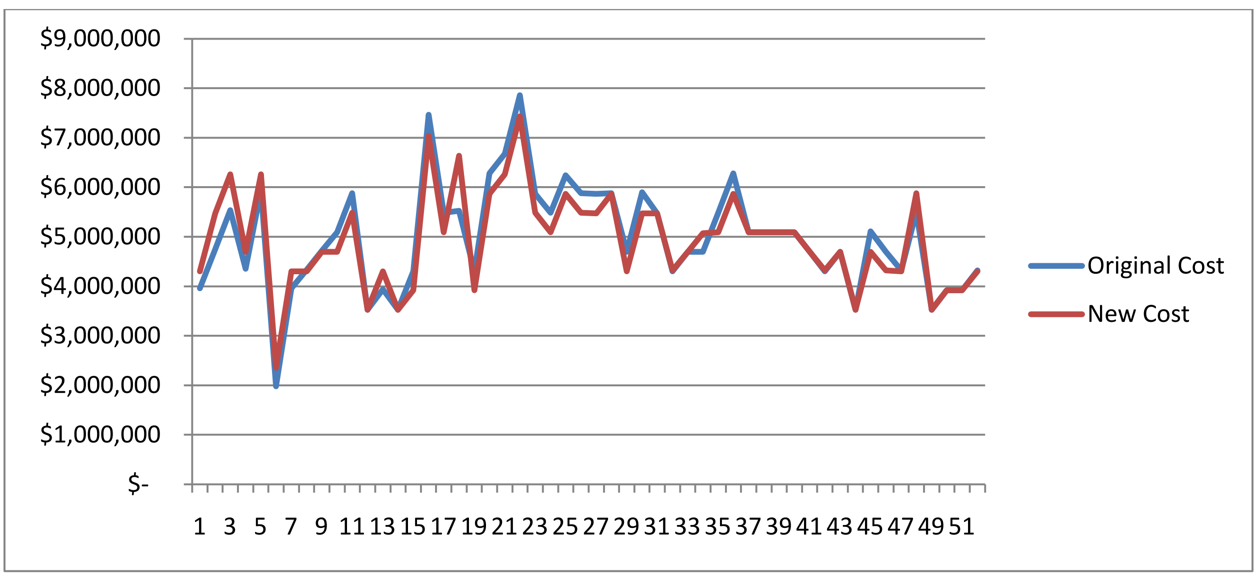

Figure 12. Weekly cost of contracted airlift, Model 4

Cost for B-747 and MD-11 lifts were taken directly from TACC's channel shop and were $395,660 for a B-747 mission and $378,076 for a MD-11 mission. The final numbers this researcher obtained resulted in 24% of lift being contracted to MD-11s at a savings of $2,646,492. This does not include the savings achieved from avoiding mission cancellation. However, as those numbers vary based on the time the mission was cancelled and that information was not readily available, this financial analysis does not take that avoidance into account. Full results broke down by each week can be seen in Appendix C.

V. Conclusions and Recommendations

The previous chapter analyzed and evaluated results of changing how many contoured pallets are built as a proportion as a whole on the cargo flow from Dover AFB to Incirlik AB, Turkey. This chapter addresses applications for this research, areas for further research, and concluding remarks.

Applications for this Research

This research demonstrates that there is a potential for savings by moving more cargo to pallets built to be compatible with contoured requirements. This is particularly true of pallets built at the Dover AFB aerial port. By examining ways to apply cargo redistribution USTRANSCOM can direct more contoured pallets to be built without causing more actual missions to be generated, which will, if nothing else, avoid the costs of cancelling MD-11 missions.

Additionally, further research is warranted into how changing the amount of airlift allocated to contoured carriers will affect CRAF participation. CRAF research is ubiquitous and seemingly constant with many studies having been accomplished in the past decade. That being said, there is no certain notion of what would be the exact response if USTRANSCOM was to reduce the percentage of cargo missions awarded to contoured carriers now that USTRANSCOM has increased the amount to 20%. Nor is there reliable information to the effect increasing the percentage of missions awarded to contoured carriers would have on non-contoured carrier participation in CRAF.

Areas for Further Research

While Model 4 was fairly restrictive in its initial parameters, there were surely items on the pallets deemed eligible for redistribution that were, in fact, not capable of being redistributed, or at least not capable of being redistributed in an efficient manner. It would be quite useful to survey what types of cargo are moving on which routes to examine exactly what percentage of cargo is capable of this redistribution. Further research may determine that cargo demanded at certain APODs lends itself to building contour-compatible pallets more effectively than other APODs.

It is important to note that changing the way pallets are built for the APOD not only effects the operation at that port and the aircraft used to move the pallets but also the operation at the APOE downrange. Taking AMCs pure-pallet concept into consideration, more study is merited to examine the effects of adjusting building of contoured pallets at the APOE and how that affects port hold times in positive or negative ways.

Comparing wide-body aircraft that require pallets to be contoured (e.g. MD-11) with those that do not (e.g. B-747) opens up additional questions as to the inherent efficiencies of each of those aircraft in the DoD transportation network. Currently carriers are flying both traditional MD-11 models and newer, more efficient MD-11F models. Likewise, those carriers that operate B-747s fly the -100, -200 and -400 models with -800 models soon to come. As with most airframes, the newer models have cheaper operating costs per ton-mile as they have newer engines that are more fuel efficient, have updated avionics systems that requires a smaller crew, and in the case of the newer B-747s can actually accommodate more cargo over a greater range. There is opportunity here for research into whether a 20% allocation to contoured aircraft is the most efficient and should be adjusted to maximize the cost-effective use of CRAF partner airframes.

Additionally, further examination of the various types of cargo shipped to the AOR can help lead to efficiencies when using MD-11 service. Some types of cargo, such as ammunition, weigh much more for a given volume than others (e.g. MREs). This cargo usually travels on pallets with smaller profiles since its weight does not allow it to be stacked to full height on a pallet. Examining the flow of these types of cargo can help efficiency by planning contoured requirements to take advantage of the fact that while moving these pallets underutilizes volume available, it makes use of pallet positions and weight capacity of lift, saving the less dense material stacked to full height for B-747s.

Finally, AMC and USTRANSCOM take the position that B-747s are more efficient and cost effective than MD-11s for moving cargo. This is certainly true when assuming full utilization of the capacity of each aircraft. But it would be worthwhile to study at what volume and weight utilization rates the MD-11 surpasses the B-747 in efficiency, if it ever does. This study could lead to better planning of pallet build distributions between full cubed pallets and contour compatible pallets.

Concluding Comments

The battle between efficiency and effectiveness is a never-ending one. In the business of the military effectiveness should, and will, always come first. However, this drive towards effectiveness leads towards criticism that AMC and USTRANSCOM are not always being as efficient as they could be. While there is some truth to them, numerous comparisons to private companies like FedEx regarding efficiency often fail to take into account the critical differences between the missions and purposes of those organizations.

This research shows that there are opportunities to improve the system by building more contoured pallets, rather than a focus on maximizing the cube volume of as many pallets as possible. It will take further research to determine the exact ratio that maximizes efficiency but there is certainly a case to build more contoured pallets.

Finally, a key area that plays into all of this is the utilization of CRAF participants in routine contract airlift. While this utilization is a major incentive for air carriers to participate in CRAF, it sometimes drives behavior that is not as efficient as it could be in order to maintain a program in CRAF that is absolutely vital to the war plans of the United States of America. It is up to USTRANSCOM leadership to determine what inefficiencies he is willing to accept in one part of the transportation network in order to allow another, key portion of that network to survive. It is hoped this research helps contribute to the body of knowledge that is used to make such decisions.

The researcher addressed the topic of contour pallets in hopes to provide more knowledge to AMC and USTRANSCOM that better strategies in building pallet types could be developed and used to avoid needless costs in the transportation system and perhaps even make the current system more efficient in addition to removing superfluous costs.

Appendix A

Pallet Volumes for B-747

L (in)	W (in)	H (in)	Vol (ft^3)	L (in)	W (in)	H (in)	Vol (ft^3)	L (in)	W (in)	H (in)	Vol (ft^3)
88	108	1	5.06	88	108	41	207.28	88	108	81	409.50
88	108	2	10.11	88	108	42	212.33	88	108	82	414.56
88	108	3	15.17	88	108	43	217.39	88	108	83	419.61
88	108	4	20.22	88	108	44	222.44	88	108	84	424.67
88	108	5	25.28	88	108	45	227.50	88	108	85	429.72
88	108	6	30.33	88	108	46	232.56	88	108	86	434.78
88	108	7	35.39	88	108	47	237.61	88	108	87	439.83
88	108	8	40.44	88	108	48	242.67	88	108	88	444.89
88	108	9	45.50	88	108	49	247.72	88	108	89	449.94
88	108	10	50.56	88	108	50	252.78	88	108	90	455.00
88	108	11	55.61	88	108	51	257.83	88	108	91	460.06
88	108	12	60.67	88	108	52	262.89	88	108	92	465.11
88	108	13	65.72	88	108	53	267.94	88	108	93	470.17
88	108	14	70.78	88	108	54	273.00	88	108	94	475.22
88	108	15	75.83	88	108	55	278.06	88	108	95	480.28
88	108	16	80.89	88	108	56	283.11	88	108	96	485.33
88	108	17	85.94	88	108	57	288.17				
88	108	18	91.00	88	108	58	293.22				
88	108	19	96.06	88	108	59	298.28				
88	108	20	101.11	88	108	60	303.33				
88	108	21	106.17	88	108	61	308.39				
88	108	22	111.22	88	108	62	313.44				
88	108	23	116.28	88	108	63	318.50				
88	108	24	121.33	88	108	64	323.56				
88	108	25	126.39	88	108	65	328.61				
88	108	26	131.44	88	108	66	333.67				
88	108	27	136.50	88	108	67	338.72				
88	108	28	141.56	88	108	68	343.78				
88	108	29	146.61	88	108	69	348.83				
88	108	30	151.67	88	108	70	353.89				
88	108	31	156.72	88	108	71	358.94				
88	108	32	161.78	88	108	72	364.00				
88	108	33	166.83	88	108	73	369.06				
88	108	34	171.89	88	108	74	374.11				
88	108	35	176.94	88	108	75	379.17				
88	108	36	182.00	88	108	76	384.22				
88	108	37	187.06	88	108	77	389.28				
88	108	38	192.11	88	108	78	394.33				
88	108	39	197.17	88	108	79	399.39				
88	108	40	202.22	88	108	80	404.44				

Appendix B

Pallet Volumes for MD-11 contoured pallet

L (in)	W (in)	H (in)	Vol (ft^3)	L (in)	W (in)	H (in)	Vol (ft^3)	L (in)	W (in)	H (in)	Vol (ft^3)
88	108	1	5.06	88	108	41	207.28	88	108	81	366.2
88	108	2	10.11	88	108	42	212.33	88	108	82	369.9
88	108	3	15.17	88	108	43	217.39	88	108	83	373.7
88	108	4	20.22	88	108	44	222.44	88	108	84	377.4
88	108	5	25.28	88	108	45	227.50	88	108	85	381.2
88	108	6	30.33	88	108	46	232.56	88	108	86	384.9
88	108	7	35.39	88	108	47	237.61	88	108	87	388.6
88	108	8	40.44	88	108	48	242.67	88	108	88	392.4
88	108	9	45.50	88	108	49	246.4	88	108	89	396.1
88	108	10	50.56	88	108	50	250.2	88	108	90	399.9
88	108	11	55.61	88	108	51	253.9	88	108	91	403.6
88	108	12	60.67	88	108	52	257.6	88	108	92	407.4
88	108	13	65.72	88	108	53	261.4	88	108	93	411.1
88	108	14	70.78	88	108	54	265.1	88	108	94	414.8
88	108	15	75.83	88	108	55	268.9	88	108	95	418.6
88	108	16	80.89	88	108	56	272.6	88	108	96	422.3
88	108	17	85.94	88	108	57	276.4				
88	108	18	91.00	88	108	58	280.1				
88	108	19	96.06	88	108	59	283.8				
88	108	20	101.11	88	108	60	287.6				
88	108	21	106.17	88	108	61	291.3				
88	108	22	111.22	88	108	62	295.1				
88	108	23	116.28	88	108	63	298.8				
88	108	24	121.33	88	108	64	302.6				
88	108	25	126.39	88	108	65	306.3				
88	108	26	131.44	88	108	66	310.0				
88	108	27	136.50	88	108	67	313.8				
88	108	28	141.56	88	108	68	317.5				
88	108	29	146.61	88	108	69	321.3				
88	108	30	151.67	88	108	70	325.0				
88	108	31	156.72	88	108	71	328.8				
88	108	32	161.78	88	108	72	332.5				
88	108	33	166.83	88	108	73	336.2				
88	108	34	171.89	88	108	74	340.0				
88	108	35	176.94	88	108	75	343.7				
88	108	36	182.00	88	108	76	347.5				
88	108	37	187.06	88	108	77	351.2				
88	108	38	192.11	88	108	78	355.0				
88	108	39	197.17	88	108	79	358.7				
88	108	40	202.22	88	108	80	362.4				

Appendix C

Model 4 Cost Analysis

	Original			New			
Week	B747	MD11	Cost	B747	MD 11	Cost	Difference
1	10	0	$ 3,956,600	8	3	$ 4,299,508	($342,908)
2	12	0	$ 4,747,920	10	4	$ 5,468,904	($720,984)
3	14	0	$ 5,539,240	12	4	$ 6,260,224	($720,984)
4	11	0	$ 4,352,260	9	3	$ 4,695,168	($342,908)
5	15	0	$ 5,934,900	12	4	$ 6,260,224	($325,324)
6	5	0	$ 1,978,300	5	1	$ 2,356,376	($378,076)
7	10	0	$ 3,956,600	8	3	$ 4,299,508	($342,908)
8	10	1	$ 4,334,676	8	3	$ 4,299,508	$35,168
9	10	2	$ 4,712,752	9	3	$ 4,695,168	$17,584
10	10	3	$ 5,090,828	9	3	$ 4,695,168	$395,660
11	12	3	$ 5,882,148	11	3	$ 5,486,488	$395,660
12	7	2	$ 3,525,772	7	2	$ 3,525,772	$0
13	9	1	$ 3,939,016	8	3	$ 4,299,508	($360,492)
14	7	2	$ 3,525,772	7	2	$ 3,525,772	$0
15	8	3	$ 4,299,508	8	2	$ 3,921,432	$378,076
16	16	3	$ 7,464,788	13	5	$ 7,033,960	$430,828
17	11	3	$ 5,486,488	10	3	$ 5,090,828	$395,660
18	13	1	$ 5,521,656	12	5	$ 6,638,300	($1,116,644)
19	8	3	$ 4,299,508	8	2	$ 3,921,432	$378,076
20	13	3	$ 6,277,808	11	4	$ 5,864,564	$413,244
21	14	3	$ 6,673,468	12	4	$ 6,260,224	$413,244
22	17	3	$ 7,860,448	14	5	$ 7,429,620	$430,828
23	11	4	$ 5,864,564	11	3	$ 5,486,488	$378,076
24	11	3	$ 5,486,488	10	3	$ 5,090,828	$395,660
25	11	5	$ 6,242,640	11	4	$ 5,864,564	$378,076
26	12	3	$ 5,882,148	11	3	$ 5,486,488	$395,660
27	11	4	$ 5,864,564	10	4	$ 5,468,904	$395,660
28	12	3	$ 5,882,148	11	4	$ 5,864,564	$17,584

	Original			New			
Week	B747	MD11	Cost	B747	MD 11	Cost	Difference
29	9	3	$ 4,695,168	8	3	$ 4,299,508	$395,660
30	13	2	$ 5,899,732	10	4	$ 5,468,904	$430,828
31	10	4	$ 5,468,904	10	4	$ 5,468,904	$0
32	8	3	$ 4,299,508	9	2	$ 4,317,092	($17,584)
33	9	3	$ 4,695,168	9	3	$ 4,695,168	$0
34	9	3	$ 4,695,168	9	4	$ 5,073,244	($378,076)
35	11	3	$ 5,486,488	10	3	$ 5,090,828	$395,660
36	13	3	$ 6,277,808	11	4	$ 5,864,564	$413,244
37	10	3	$ 5,090,828	10	3	$ 5,090,828	$0
38	10	3	$ 5,090,828	10	3	$ 5,090,828	$0
39	10	3	$ 5,090,828	10	3	$ 5,090,828	$0
40	10	3	$ 5,090,828	10	3	$ 5,090,828	$0
41	9	3	$ 4,695,168	9	3	$ 4,695,168	$0
42	8	3	$ 4,299,508	9	2	$ 4,317,092	($17,584)
43	9	3	$ 4,695,168	9	3	$ 4,695,168	$0
44	7	2	$ 3,525,772	7	2	$ 3,525,772	$0
45	11	2	$ 5,108,412	9	3	$ 4,695,168	$413,244
46	9	3	$ 4,695,168	9	2	$ 4,317,092	$378,076
47	9	2	$ 4,317,092	8	3	$ 4,299,508	$17,584
48	12	2	$ 5,504,072	12	3	$ 5,882,148	($378,076)
49	7	2	$ 3,525,772	7	2	$ 3,525,772	$0
50	8	2	$ 3,921,432	8	2	$ 3,921,432	$0
51	8	2	$ 3,921,432	8	2	$ 3,921,432	$0
52	9	2	$ 4,317,092	8	3	$ 4,299,508	$17,584
total	538	122	$ 258,990,352	495	160	$ 256,343,860	$2,646,492
total		660			655		
% MD-11		**18%**			**24%**		

Appendix D

APOD-Airfield Decoder

APC	Airfield
3OR	Al Asad, Iraq
AZ1	Bastion, Afghanistan
BSR	Basra, Iraq
KDH	Kandahar, Afghanistan
KIK	Kirkuk, Iraq
O2R	Al Sahra, Iraq
O6R	Tall Afar, Iraq
OA2	Shindad, Afghanistan
OR9	Balad, Iraq
O8M	Mosul, Iraq
SDA	Baghdad, Iraq
TA8	Ali Base, Iraq
TE2	Tereen, Afghanistan

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Effects of Contour Pallets on AMC Mission Efficiency

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Introduction

Utilization of civilian carriers to moved cargo for TRANSCOM has been critical to DoD operations around the globe and particularly to operations in Iraq and Afghanistan. However, using CRAF participation to determine how many missions carriers get access to has proved problematic at times as carriers have pledged aircraft, such as the MD-11 to CRAF that are well-suited to that program but are not as efficient as other aircraft, such as the Boeing 747, during current operations.

Using modeling analysis of cargo movement on these two airframes over the past fiscal year, this research examined the potential to improve the overall efficiency of this portion of TRANSCOM's global transportation network while maintaining critical incentives provided to civilian carriers that are needed to sustain the CRAF program.

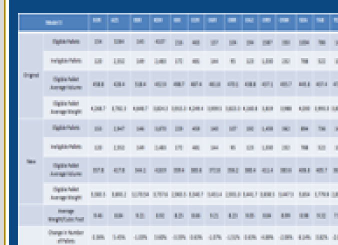
Research Goals

- Identify potential for redistribution of cargo from full cube pallets to those with a contour profile
- Investigate efficiency of redistribution related to both pallet build location and final destination
- Utilize the model to analyze the financial impact of changing percentage of airlift allocated to different aircraft types

AIR FORCE INSTITUTE of TECHNOLOGY

General Framework

Application – Pallet Building



Motivation

- Current directives to maximize certain portions of cargo movement (weight, cube) don't take into account effects on other aspects of the transportation system
- Introducing another aspect of efficient utilization, even at the costs of other metrics could improve the overall system efficiency which is the ultimate goal

Impacts/Contributions

- Identified the potential for cost savings using commercial lift without any cost to effectiveness

Collaboration

618th Air and Space Operations Center, Channel Division

Headquarters AMC – A9

Blue Dart Submission Form

First Name: __James______________ Last Name: ___Hanford_____________________

Rank (Military, AD, etc.): __Major_________

Position/Title: _Student, ASAM____

Phone Number: ___650-7740________ E-mail: _james.hanford@us.af.mil_____ ______

School/Organization: _AFIT/ASAM____

Status: [X] Student [ ] Faculty [ ] Staff [ ] Other

Optimal Media Outlet (optional): ____

Optimal Time of Publication (optional): _____________________________________
{*e.g., anniversary of a specific event, etc.*}

General Category / Classification:
[ ] core values
[ ] war on terror
[ ] warfighting
[X] command
[ ] culture & language
[ ] international security
[ ] strategy
[ ] leadership & ethics
[ ] doctrine
[ ] other (specify): ____

Suggested Headline: __Effect of Contour Pallets on AMC Mission Efficiency_________
{*e.g., I Was Just Following Orders*}

Keywords: ___Inter-theatre Distribution, Pallet, Palletized cargo, Cargo distribution, B-747, MD-11_____
{*e.g., leadership, ethics, Nuremburg, Giessen, intimidation, chain of command*}

Blue Dart Text {either type in or cut and paste from another document}—Limit to approximately 750 words:

Civilian carriers are an important part of the Air Mobility Command's channel system and the US Transportation Command's (USTRANSCOM) global transportation network. Two of the civilian workhorses in this process are the Boeing 747 (B-747) and MD-11 aircraft.

The Civilian Reserve Air Fleet (CRAF) program plays a large role in the selection what carriers gain access to what quantities of contracted missions. While a large portion of the aircraft made available to CRAF are contoured carriers like MD-11s, the Department of Defense moves most of its cargo on B-747s they are believed to be a more efficient platform when loaded to capacity. Recently issues have arisen as carriers operating MD-11s feel that they have not been awarded an adequate share of contracted channel missions. Thus, USTRANSCOM made the mandate that 20% of global channel cargo missions would be awarded to contoured carriers. This has resulted in numerous cancellations of MD-11 missions due to a lack of compatible cargo available for movement, decreasing overall efficiency and increasing costs.

An analysis of pallet data of cargo moving between Dover AFB, Delaware and Incerlik AB, Turkey over a one-year period showed that there is a potential for numerous opportunities to increase the number of pallets built to contour requirements without a drastic increase in overall pallets built.

The researcher developed four models in Excel, beginning with a general model with few assumptions that was not realistic but useful for illustrative purposes. This followed all the way through to the fourth model which had numerous restrictions designed to maximize realism based on the available information. All financial and modeling of missions required to move the cargo were based on the fourth and most realistic model.

Additionally these opportunities were not found to be system-wide but rather greater at the aerial port of Dover AFB and much less so than the Defense Logistics Agency's (DLA) distribution operation at Susquehanna. Both locations had potential to increase overall efficiency by building more contoured pallets but the potential for improvement was far more pronounced at Dover AFB. The research did not cover if this was true of the relationship between other aerial ports and DLA facilities.

This analysis showed that by maximizing pallets built to contour dimensions rather than full cubes could result in potential reduction in total pallets of about 2.5%, broke down to a pallet reduction of approximately 13% from pallets built at Dover AFB and an increase in pallets required of about 2% from Susquehanna. There was no significant difference in this potential when pallets were analyzed based on their final destinations.

When compared to contracted airlift rates on the Dover AFB to Incerlik AB mission, a total savings of just over $2.4 million was simulated. While the model used, as with all models, is not perfectly suited to all conditions in the real world and this savings may not be fully realizable, the research still suggests a strong potential for savings by increasing the effort to build contour-compatible pallets.

This research provides a good starting point in the process of deciding what proportion of pallets should be built to contour requirements or even if all possible pallets should be built to contour requirements.

To improve mission efficency of contracted airlift, USTRANSCOM should be prepared to sacrifice maximization of aggregate cube utilization in return for maximizing total airlift utilization efficiency and thus lowering overall costs. The potential of unintended consequences cannot be overstated as USTRANSCOM and AMC pick metrics to maximize if careful thought isn't given to second and third-order effects. By including these thoughts in continuing analysis of the benefits in producing more contoured pallets AMC and USTRANSCOM can increase the efficiency of channel airlift while boosting civilian carriers desire to participate in CRAF.

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14. ABSTRACT
Research analyzed cargo moved on 747s and MD-11s between Dover AFB and Incirlick AB in FY2009 to determine effects of redistributing cargo from cubes to contoured shapes. The research analyzed pallet build strategies to ensure that MD-11 missions were not cancelled due to lack of available contour-compatible cargo while other, full-cubed cargo was available. Data obtained from Air Mobility Command was used to construct 4 models examining redistribution effects. The data consisted of over 22,000 pallets moved on over 600 missions. The models demonstrated opportunities to restructure cargo exist with the potential to not only avoid future costs due to cancellation fees but also increase system efficiency as a whole.

15. SUBJECT TERMS
Inter-theatre Distribution, Pallet, Palletized cargo, cargo redistribution, B-747, MD-11

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